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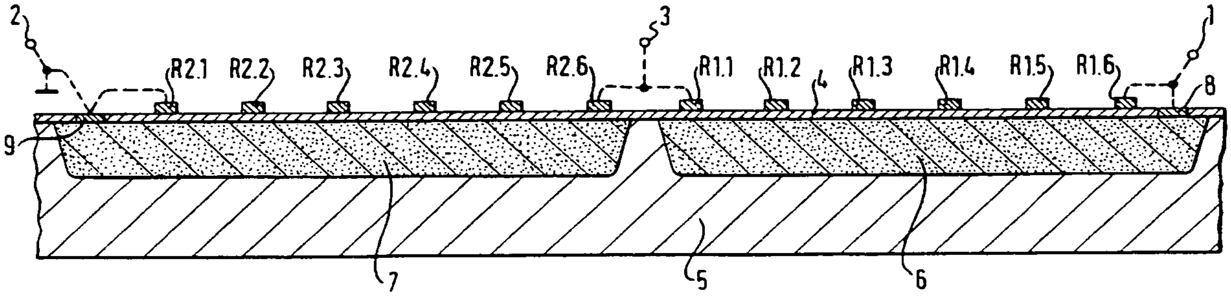
(54) Integrated voltage divider.

(57) An integrated voltage divider contains partial resistors (R1,R2) of paths of polycrystalline semiconductor material applied over a dielectric layer (4) on a semiconductor substrate (5). Under the paths each forming a partial resistor (R1,R2) in the semiconductor substrate (5) a well (6 and 7 respectively) is formed having a conductivity type opposite to the conductivity type of the semiconductor substrate (5). The total surfaces of the paths forming the partial resistors (R1,R2) are dimensioned so that their ratio equals the inverse ratio of the resistor values of the two partial resistors (R1,R2).

Fig. 2



The invention relates to an integrated voltage divider comprising a first resistor in series with a second resistor, in which the voltage to be divided can be applied to the ends of the series circuitry of the two resistors and the divided voltage can be output at the point connecting the two resistors.

Voltage dividers are typically produced by connecting, for example, two partial resistors in series, at the common connecting point of which part of the voltage applied to the series circuit can be output. As a rule, one end of such a series circuit of the two resistors is connected to a low potential whilst the other end of the series circuit is connected to a point in the circuit of higher potential, the ratio of the drop in voltage across the one partial resistor as compared to that of the other corresponding to the ratio of the resister values.

When a voltage divider of the aforementioned kind is used to divide an HF voltage or a square-wave voltage having a steep slope, the unavoidable stray capacitances accompanying the partial resistors become a disadvantage since the waveform of the divided voltage no longer corresponds to the waveform of the input voltage of the voltage divider. With square-wave voltages these stray capacitances lead, for example, to a more or less pronounced overshoot on the pulse slopes. In a voltage divider used as the input divider of an oscilloscope this behaviour is particularly a nuisance since the negative effects of the stray capacitances are directly evident on the screen, the viewer then not knowing whether he is seeing the correct signal shape corresponding to the input signal or a signal shape which is changed due to the stray capacitances. The effects of the stray capacitances are all the more serious, the higher the frequencies involved and the higher the impedance of the partial resistors.

For frequency compensation of the voltage divider the partial resistors can each be connected in parallel with capacitors which are dimensioned so that the products of the resister value of the partial resister and the correspondingly assigned capacitor are the same.

When producing a voltage divider in integrated circuit technology the frequency compensation cannot be attained by connecting the integrated capacitors in parallel with the integrated partial resistors. In the case of integrated partial resistors the stray capacitances are distributed over the full geometrical area of the resistor body and they must not necessarily be located between the two ends of the partial resistor. Apart from this, a considerable stray capacitance with respect to GND exists.

The object of the invention is to create an integrated voltage divider of the kind as mentioned at the outset, the output voltage profile of which represents the input voltage profile irrespective of the frequency of the input voltage.

The invention achieves this object in that the resistors are formed of paths of polycrystalline semiconductor material over a dielectric layer which is in turn provided on a semiconductor substrate, that in said semiconductor substrate under each path forming a resistor a well is formed having a conductivity type opposite to the conductivity type of said semiconductor substrate, said well assigned to said resister being connected to the one end of the series circuit and the well assigned to said second resistor being connected to the other end of the series circuit and that the total surfaces areas of the paths forming the separate individual resistors is dimensioned so that their ratio equals the inverse ratio of the resistor values of the two resistors.

In an integrated voltage divider of a type according to the invention, providing the resistors over wells separated in the substrate from each other enables the common points of all stray capacitances assigned to a single resistor to be applied to a suitable bias, namely to the voltage at one end of the series circuit or to the voltage at the other end of the series circuit by means of the corresponding well. Defining the surface areas of the paths forming the corresponding resistors causes the products of resistance and stray capacitance at the two resistors to be equal in each case, as is necessary for the wanted frequency compensation.

Further advantageous embodiments of the invention are characterized in the subclaims. By means of the further embodiment as characterized in subclaim 2 higher accuracy can be achieved in defining the resistor values. The embodiment of subclaim 4 permits compensating the mechanical stresses to which the integrated circuit containing the integrated voltage divider may be exposed. The further embodiment of claim 4 serves to compensate the inductances of the conducting paths. By means of the further embodiment characterized by subclaim 5 the effects of temperature on the integrated voltage divider can be compensated.

An example of an embodiment of the invention will now be explained in more detail with reference to the drawing in which:

Figure 1 is an equivalent circuit of an integrated voltage divider according to the invention,

Figure 2 is a schematic side view of part of an integrated circuit containing a voltage divider according to the invention; and

Figure 3 is a plan view of an integrated voltage divider according to the invention in an embodiment as achieved in actual practice to illustrate the course of the paths forming the divider resistors.

The voltage divider shown in Figure 1 contains two resistors R1 and R2 which are preferably partial resistors and are combined as individual resistors R1.1 thru R1.6 or R2.1 thru R2.6 into a series circuit. This type of representation has been chosen to permit depicting the stray capacitances which in an integrated circuit are not present as individual discrete components but distributed. In Figure 1 these stray capacitances are identified assigned to the partial resistors R1 and R2 as separate capacitors C1.1 thru C1.5 and C2.1 thru C2.5 respectively. The voltage to be divided is applied between the input 1 of the voltage divider and point 2 connected to GND. The divided voltage can be taken from the output 3.

The individual resistor R1.1 thru R1.6 and R2.1 thru R2,6 have the form of paths of polycrystalline silicon as evident from the section in Figure 2. The connections of the individual paths to form the partial resistors R1 and R2 are produced by a suitable configured metallization layer over the paths as is generally practised in integrated circuit technology. This metallization layer is not shown in the drawing to provide a better overview. The connections are indicated merely schematically by dashed lines.

As is evident from Figure 2 the individual resistors of the partial resistors R1 and R2 are provided on a thin layer 4 of polycrystalline silicon applied to the surface of a semiconductor substrate 5. This semiconductor substrate 5 comprises P-conducting silicon, for example. Under the paths forming the partial resistor R1 and under the paths forming the partial resistor R2 a well 6 and 7 respectively of N-conducting silicon is provided, as evident from Figure 2. Via a connecting contact 8 the well 6 is connected to the input 1 of the voltage divider, whilst the well 7 is connected to the GND point 2 of the voltage divider via a connecting contact 9.

In the voltage divider as shown in Figure 2 the layer 4 of polycrystalline silicon has the effect of a dielectric of the stray capitances forming underneath the paths constituting the individual resistors, the path of an individual resistor forming in each case the plate of the stray capacitance assigned to it whilst the well located underneath forms in common the other plate of all stray capacitances. To eliminate the frequency dependency of the transfer characteristic of the integrated voltage divider as shown in Figure 2 it must be ensured that the stray capacitances assigned to the separate partial resistors R1 and R2 behave inversely to the resistor values of the partial resistors. Since the stray capacitances are directly proportional to the surface areas of the paths forming the individual resistors the aforementioned condition can be satisfied for achieving frequency compensation by influencing the surface areas of the paths.

Since achieving high accuracy of the resistor values and, in particular, achieving good reproducibility of the precise resistor values makes it necessary to use paths of equal width for the individual resistors, the surface area of the paths cannot be made larger simply by making use of wider paths when higher capacitance values are required. The requirement that the capacitance values assigned to the individual resistors must behave inversely to the resistor values involves two conflicting conditions. A small resistor value could be achieved by a short path length, however, this would produce, due to the assumed equal path width, also a correspondingly small surface area and a correspondingly small stray capacitance. A resistor having a small value must, however, have an assigned stray capacitance having a high capacitance value so that the condition for the frequency compensation is satisfied. A small resistor value is thus achieved by dividing a long resistor path, producing the necessary large surface area and thus high capacitance, into several individual resistors and by suitable parallel connection bringing it to the desired small resistor value. Since the partial resistor having the higher resistor value in the voltage divider automatically necessitates a longer path forming it, a greater stray capacitance also results automatically. Since reducing this stray capacitance in the larger partial resistor is not possible, actual practice in configuring an integrated voltage divider is to start with a larger partial resistor, the smaller partial resistor then being configured by connecting the individual paths in parallel to achieve the desired frequency compensation.

In the integrated voltage divider as shown in Figure 2 the well 6 assigned to the partial resistor R1 is connected to the input 1 to which the voltage to be divided is applied. In this way the unavoidable capacitance lies between the well 6 and the substrate 5 parallel to the input 1 so that it has no effect on the frequency compensation, it merely constituting a capacitive load on the source of the voltage to be divided. By connecting the well 7 assigned to the partial resistor R2 to GND the capacitance between the well 7 and the substrate is short-circuited so that, here too, it has no effect on the frequency compensation.

Figure 3 shows the layout of the integrated voltage divider described. From this layout the course of the paths of the partial resistors R1 and R2 is evident; the metallization layer connecting the individual points in the circuit not being shown.

As indicated, partial resistor R1 is arranged in the middle region of the surface area taken up by the voltage divider. The paths forming the partial resister R2 surround this middle region, the paths of the partial resistors taking such a course that roughly the same number of components run in one direction as in a direction perpendicular thereto. This layout is selected for several reasons. Due to the fact that the paths forming the partial resistor R2 are arranged on both sides of the partial resistor R1 temperature compensation of the voltage divider is achieved. When, for example, as shown in Figure 3 the region of the partial resistor Rs located on the right of the partial resistor R1 has a higher temperature than the region on the left, the effects of temperature on the electrical parameters of the voltage divider as regards the partial resistor R1 having a mean temperature value cancel each other out. By providing just as many paths in the one direction as in the direction perpendicular thereto a compensation as regards mechanical stresses is achieved since in this arrangement the number of paths subject to elongation and compression during mechanical stress is roughly equal.

It should be noted that the described possibility of achieving frequency compensation by configuring the surface areas of the paths forming the divider resistors can be solved mathematically exact, in actual practice, however, this cannot be achieved precisely for all divider ratios desired when, as assumed, paths of equal width are used. Nevertheless an accuracy of frequency compensation can be achieved in actual practice which is completely adequate for very many applications.

So that the inductance of the long paths employed has no effect on the frequency response of the voltage divider, partial lengths of the paths are connected to each other so that the currents in directly neighboring paths each flow in opposite directions, this corresponding to the principle of the bifilar winding of a coil.

The described integrated voltage divider is not only frequency compensated but it is also insensitive to changes in temperature or to mechanical stresses due to the layout as shown in Figure 3.

Claims

1. An integrated voltage divider comprising a first resistor in series with a second resistor, in which the voltage to be divided can be applied to the ends of the series circuiting of the two resistors and the divided voltage can be output at the point connecting the two resistors, wherein said resistors (R1, R2) are formed of paths of a semiconductor material over a dielectric layer (4) which is in turn provided on a semiconductor substrate (5), said semiconductor substrate (5) under each path forming a resistor (R1,R2) a well (6,7) is formed having a conductivity type opposite to the conductivity type of said semiconductor substrate (5), said well (6) assigned to said first resistor (R1) being connected to the one end of the series circuit and the well (7) assigned to said second resistor (R2) being connected to the other end of the series circuit, and that the total surface areas of the paths forming the separate resistors (R1,R2) are dimensioned so that their ratio equals the inverse ratio of the resistance values of the two resistors (R1,R2).

2. An integrated voltage divider according to claim 1, wherein said resistors comprise partial resistors.

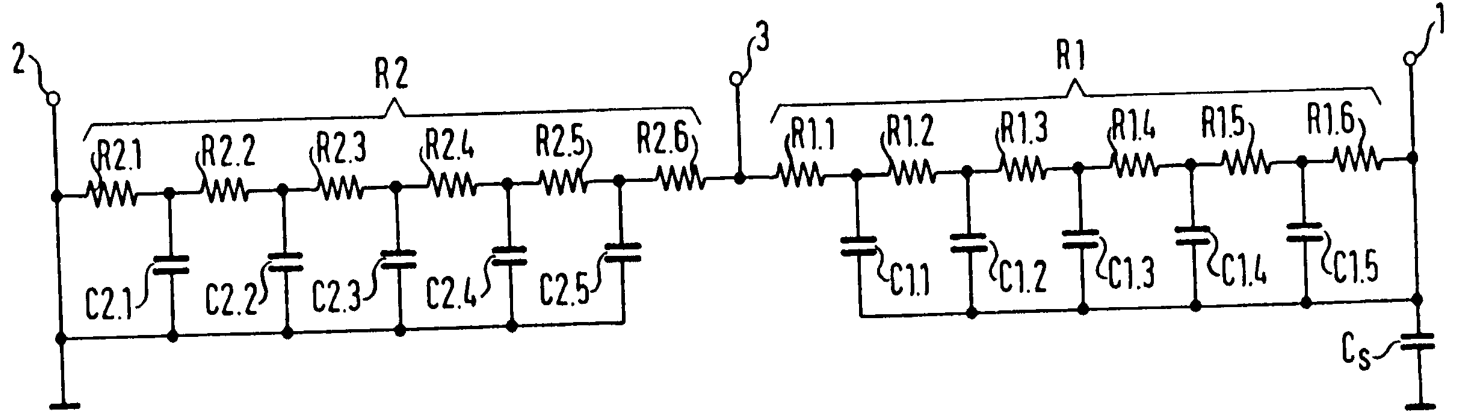
3. An integrated voltage divider according to claim 1 or claim 2, wherein the paths forming said resistors (R1,R2) have the same width and that the resistance values are defined by selected series and parallel connecting of partial lengths of the paths.

4. An integrated voltage divider according to any preceding claim, wherein the paths are arranged on the dielectric layer so that the same number of partial lengths of the paths extend in a first direction as in a second direction perpendicular thereto.

5. An integrated voltage divider according to any of the above claims, wherein partial lengths of said paths are connected to each other so that currents in directly neighboring partial lengths flow in opposite directions.

6. An integrated voltage divider according to any of the above claims, wherein the paths of said resistors (R1,R2) are arranged on said dielectric layer (4) so that the paths of said one resistor (R1) surround the surface area occupied by the paths of said other resistor (R2) in such a way that on all sides of the surrounded resistor (R2) the same number of partial lengths of the paths of the surrounding divider resistor (R1) extend.

Fig. 1


2
R2
R2.1
R2.2
R2.3
R2.4
R2.5
R2.6
C2.1
C2.2
C2.3
C2.4
C2.5
3
R1
R1.1
R1.2
R1.3
R1.4
R1.5
R1.6
C1.1
C1.2
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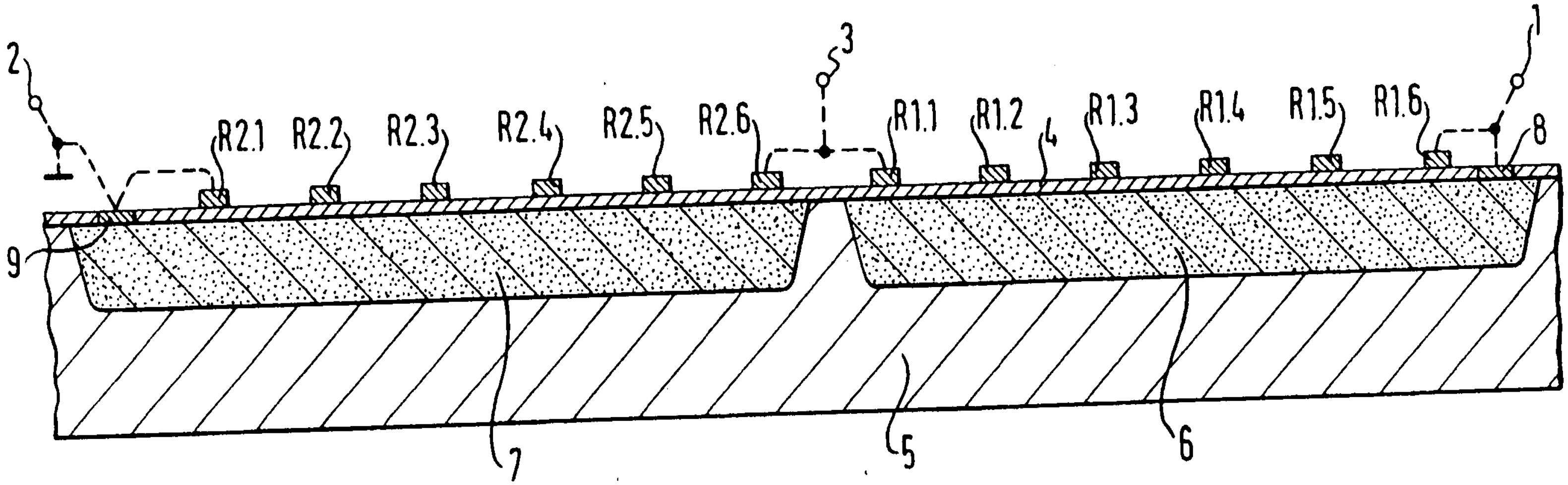
C1.5
1
C_s

Fig. 2


2
9
R2.1
R2.2
R2.3
R2.4
R2.5
R2.6
3
R1.1
R1.2
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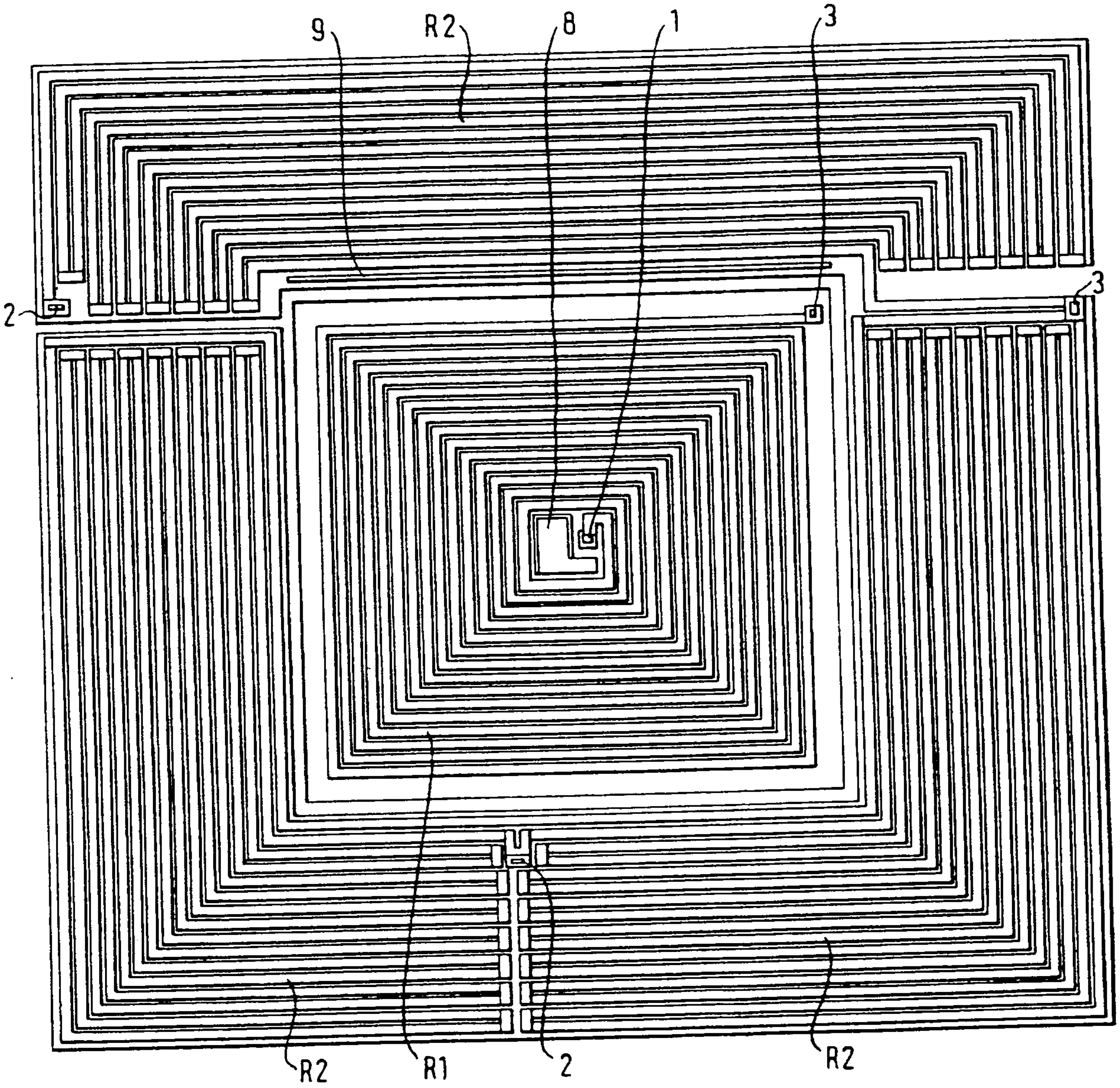
R1.3
R1.4
R1.5
R1.6
1
8
7
5
6

Fig. 3



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EUROPEAN SEARCH REPORT

Application Number

EP 93 10 7652

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 177 692 (FUJITSU LIMITED) * page 13, line 1 - line 14; figure 4 *	1-6	H01L27/06 H01L27/08
A	US-A-4 181 903 (HOLLAND ET AL.) * abstract *	1-6	
A	PATENT ABSTRACTS OF JAPAN vol. 8, no. 221 (E-271)9 October 1984 & JP-A-59 104 171 (SUWA SEIKOSHA KK) * abstract *	1-6	
A	US-A-4 620 212 (OGASAWARA) * abstract *	2-6	
A	EP-A-0 035 361 (FUJITSU LIMITED) * abstract *	6	
A	EP-A-0 289 794 (TELEFUNKEN ELECTRONIC GMBH) * abstract *	1-6	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	US-A-3 700 977 (LUNN) * column 5, line 31 - line 57; figures 1,2 *	1-6	H01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	28 SEPTEMBER 1993	ONSHAGE A.C.

CATEGORY OF CITED DOCUMENTS

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